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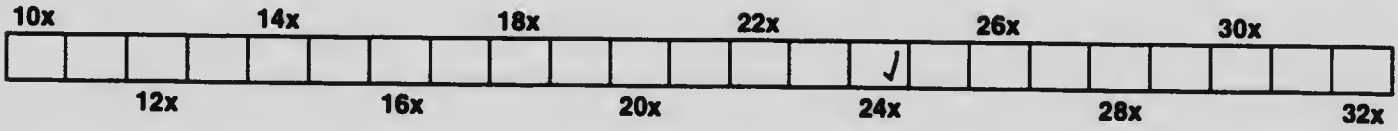


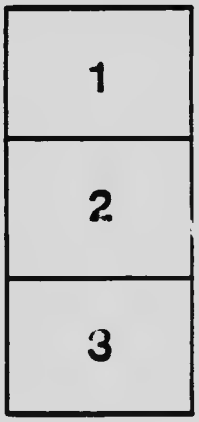


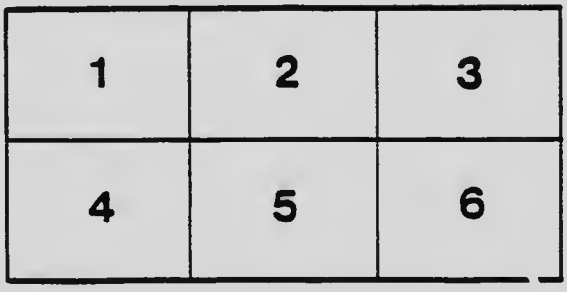

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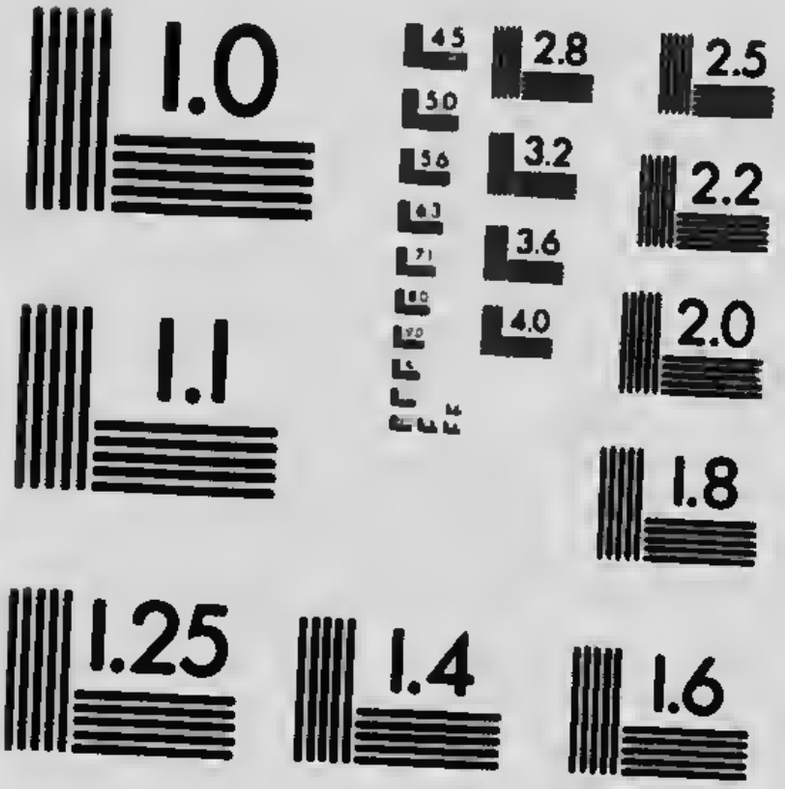


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GEOLOGICAL SURVEY OF CANADA
ROBERT BELL, M.D., D.Sc. (Cantab.), LL.D., F.R.S.

# MINERAL RESOURCES OF CANADA

## BULLETIN

ON

# APATITE

(Phosphate of Lime.)

BY
R. W. ELLS, LL.D. F.R.S.C.

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# APATITE.

By R. W. Ells.

Occurrence.

Apatite or Phosphate of lime is a mineral of wide distribution, occurring in several forms and at widely separated geological horizons. In Canada, its occurrence may be described under two heads, viz., those which belong to the crytalline rocks of what is styled the Laurentian system; and those which are found in fossiliferous strata of Cambrian or Cambro-Silurian age.

Organic phosphate.

In several of the earlier reports of the Geological Survey attention was directed by Dr. T. S. Hunt to the latter class of deposits. These are found principally in the form of phosphatic nodules in certain limestones, shales and sandstones at different points in the Ottawa valley as well as at places along the lower St. Lawrence. They were held at the time to be of considerable economic importance, when properly prepared, as a valuable fertilizer for certain soils of the district. Practically no attempt has ever been made to demonstrate their utility in this respect; and in view of the great abundance of the mineral apatite in certain parts of the province of Quebec north of the Ottawa river, as well as in some portions of eastern Ontario, their commercial development will probably not be attempted.

Crystalline apatite.

Apatite as found in the crystalline rocks came markedly into prominence as a source of mineral wealth about thirty years ago. It is found in connection with certain rock masses which traverse the gneisses and limestones of the Grenville series and which have long been regarded as forming the uppermost division of the Laurentian. The mineral is of varying colours, generally a sea-green, but sometimes red, brown or greyish-white, and is generally in the massive or rock condition known as "rock phosphate" but sometimes occurs as a finely granular material when it is known as "sugar phosphate." In the process of mining, the former is more readily handled as it can be extracted in clean condition or in such form that it can be easily cobbed from the enclosing rock; while the latter is easily broken up, and though of equal value with the massive variety, is readily mixed with foreign substances, and is therefore apt to be classed as of lower grade.

Composition.

Apatite has a hardness of 4½ to 5, and in composition consists of phosphate of lime 90 to 92 per cent, with fluoride of calcium 4·6 to 7·7, and small amounts of calcium chloride and of insoluble matter. The mineral therefore both of the Quebec and Ontario districts belongs to the variety known as fluor-apatites. In the rock it is found both in a massive state in pockets of all sizes, sometimes reaching thousands of tons which are distributed in a greyish-green pyroxene; and as crystals in a matrix of calcite, either pink or white, which forms an integral portion of these intrusive masses or dykes.

The presence of apatite in the Laurentian rocks of Canada was first announced by Lieut. Ingall, in 1829, as occurring near the Lièvre river in Buckingham township; and it may be remarked that in this area some of the largest and most valuable mines of this mineral were subsequently located and worked for a number of years with great profit.

History of development.

Little attention was however attached to the discovery at that early date, and for nearly half a century its economic value was not realized. In the Geological Survey Report for 1847, Dr. Hunt referred to the presence of the mineral as occurring in the township of North Burgess in Ontario, in rocks of similar character to those in which it was found in Quebec. Mining in the district did not however commence for many years, the Burgess deposit being first opened by

Ontario.

quarrying about 1860. From this date to 1875 the annual output from the Ontario mines was scarcely more than 1,000 tons annually, the mineral being for the most part obtained from shallow surface pits, though on lot 10 range VI, two shafts were sunk to depths of 134 and 75 feet respectively.

Quebec.

In the province of Quebec phosphate mining was commenced in 1871, when a few tons were taken out near the Little Rapids on the Lièvre river apparently in Buckingham township. Development in this district was however much more rapid than in Ontario, as the value of the mineral was by this time much better known, while the deposits were much more extensive. In 1878 the output for this part of the province of Quebec amounted to 3,000 tons. Eight years later this had increased to 28,535 tons, valued at $490,331. The largest output for the province of Ontario was in 1889 when it reached the amount of 3,547 tons, valued at $38,833. This in 1894, the last year in which figures of production are given, was reduced to 1890 tons valued at $10,560, while in the province of Quebec the output subsequent to 1891 also rapidly decreased and in 1895 the exports amounted to only 250 tons valued at $2,500. The chief causes which led to this

decline in such an important mining industry was the exploitation of the cheaply mined phosphates of the southern states of Carolina, Georgia, &c. At the close of the industry in Ontario and Quebec the amount of the mineral in sight at the principal mining centres had shown no appreciable diminution.

Associated rocks.

The country rocks of the apatite bearing areas, both in Quebec and eastern Ontario, are practically the same. They consist of gneiss of various colours, sometimes garnetiferous, red, grey and black, with which are associated beds of white quartzite and crystalline limestone, the latter forming the highest member of the Grenville series in Quebec. These rocks are intersected by numerous veins and dykes, sometimes reaching masses of large dimensions, comprising diabase, pyroxene and granite, the latter including pegmatites in the form of dykes sometimes of considerable size. The pegmatite is more recent than the pyroxene since it cuts the latter in all directions, and this in turn is intersected by the diabase dykes. These features of intrusion are seen at most of the mines throughout the Lièvre or Buckingham district as well as in the township of Templeton and Hull nearer the Gatineau. Similar occurrences are always found in the apatite districts of Ontario.

Areas north of the Ottawa.

While the area of the Grenville series of rocks is of great extent the portion which carries workable deposits of apatite is comparatively limited. Thus in the province of Quebec the mines are practically confined to a belt in the vicinity of the Lièvre, in the townships of Buckingham and in Portland east and west, and further west in Templeton. Of these the most extensive and valuable are found in a well defined zone which extends nearly parallel to the Lièvre, beginning a short distance north of what is known as Chalifoux landing on the west side of the river and continuing with some interruptions to the vicinity of the High falls, a distance of about five miles. On this range some of the largest mining areas are found, including the Ross Mountain and Crown Hill, the High Rock, Star Hill, Central Lake and High Falls deposits. On the east side also a number of large mines are located beginning with the Etna, Squaw hill and the Emerald on the south, which are situated about nine miles north of Buckingham village, and extending northward for about eight miles, including in the northern part such important mining centres as Little Rapids, the North Star, and others in the area between the Lièvre and Tamo lake. In this belt the occurrences of the pyroxene are well-defined but the masses in the aggregate are not so large or so continuous as in the hill on the west side of the river.

Mode of occurrence

In many of the mines of this district, more especially in the group west of the Lièvre, the apatite is found in the massive form in pockets and irregular veins which occur in the mass of the pyroxene itself. These pockets have been described by several writers as forming true beds, but a close examination over a large series failed to show this feature. In some of the occurrences the quantity of the apatite was very large, exhibiting a chimney like structure, and where several of those were found, occurring along a fairly well defined course, the series were often connected by small stringers of the mineral, though this was by no means a universal feature. Many of these occurrences were found to be shallow isolated deposits with no indication of bedded or vein structure, and in the early days of mining much of the work was, to a large extent, confined to extracting the apatite from these surface shows, since such mining required but a small amount of capital, and when one was exhausted another could be readily found. In some of the larger mines however a system of deep mining was instituted, and before the close of the industry in 1892-93 several of the shafts and workings were carried to a depth of several hundred feet, following downward along a system of irregular veins and pockety masses which continued to the lowest depths reached.

In pyroxene.

In calcite.

In several of the mines on the east side of the Lièvre and in the Templeton and Gatineau districts as well, the conditions of occurrence appear to be somewhat different. Here the pyroxene as a rule occurs more in the form of dykes, some of which are of large size, but in these, near the contact with the surrounding gneiss, masses of pink calcite, which form an integral portion of the intrusive rocks, are seen, in which the apatite occurs in the form of crystals, associated with mica and crystals of pyroxene as well as other minerals. Some of the apatite crystals thus found are of large dimensions, reaching a weight of some hundreds of pounds, but in many the terminal angles are rounded off. The proportion of apatite contained in the calcite matrix is however usually too small to render the working of such deposits profitable. This mode of occurrence is common in the mines of the Burgess and Kingston districts in Ontario. At the present time in the process of mica mining on such deposits a large amount of this crystalline apatite is now taken out and saved as a by-product. Such occurrences are classed as veins, the foot wall being the pyroxene rock while the hanging wall is formed by the gneiss through which the original pyroxene intrusion has cut.

Calcite replaced by apatite.

In some of the mines of the Templeton district, midway between the Lièvre and Gatineau rivers, as at the Blackburn and at Battle

lake the association of the mica and apatite with the calcite is frequent. In these cases the calcite is sometimes almost entirely replaced by the apatite, and the mica, which elsewhere is found in the former as a vein filling, occurs in large masses in the latter. Similar interchanges of apatite and calcite as vein matter are observed in several of the Ontario mines as in the Sydenham district. This close association of the mica and apatite has been referred to in the Bulletin on Mica recently published.

Apatite confined to Ontario and Quebec.

In the eastern provinces of Nova Scotia and New Brunswick and in that part of Quebec, east of the St. Lawrence river, no rocks carrying this variety of apatite have been found. While in the two provinces first named there are quite large areas of the crystalline gneiss and limestones which are regarded as the equivalents, in part at least, of the Grenville series of Quebec and Ontario, similar conditions as regards the occurrence of the apatite do not appear to have prevailed. In the rocks of the western mountain region also, along the Pacific coast and throughout the Rocky mountain range in so far as these have been examined, this mineral has not yet been reported, although deposits of mica are known to occur at several points. These are however related to the granitic intrusions of that area.

Its association with pyroxene.

The crystalline apatite of the old rocks of Quebec and Ontario is always found in connection with pyroxene, which is clearly intrusive through the gneiss and crystalline limestone, and of more recent date. The old theory, maintained for many years, that these pyroxenes represented altered sediments, laid down as an integral portion of the associated gneissic and other related strata, has long since been abandoned by those who have most closely studied the field relations of the several rock groups. It is also probable, that in many cases the presence of the apatite in quantity, even in the pyroxene, is in many cases due to the action of other dykes of granite and diabase which frequently are seen traversing the former, and in close association with which some of the largest deposits have been opened. The assertion has been made by some that apatite sometimes occurs with the ordinary gneiss as well as in the pyroxene, but of this we have no evidence in so far as the Canadian deposits are concerned, where in every observed case it has been clearly established that the mineral occurs exclusively, as regards the workable mines, in connection with the intrusive pyroxene, and even in such cases as occurrences in calcite this vein matter has no relation whatever to the altered limestone, quartzite or gneiss of the Laurentian rocks.

Origin.

Origin.

The question of the origin of apatite was for some years an important one and led to much discussion. By several leading authorities, including Sir William Dawson, Dr. T. S. Hunt and others it was strongly maintained that it was of a purely organic nature, resulting from the decomposition and alteration of the earlier forms of life which were supposed to be abundant in that early time. In support of this view the supposed fossil form known as Eozoon was cited, as well as the widely disseminated occurrence of graphite in the older crystallines and of many of the iron ores, all of which were supposed by these authorities to owe their presence to organic agencies. On the other hand some persons maintained that from the mode of its occurrence in igneous rocks its presence and origin were due to causes not quite clear, but certainly not organic and probably arose from the action of phosphoric acids upon certain portions of the pyroxene, which they maintained was of igneous origin rather than an altered sediment, or to ascending vapours which were brought to the surface with the advent of the eruptive rocks with which the mineral was associated. Among the supporters of this theory in Canada may be mentioned Dr. Robert Bell, Dr. Selwyn, Mr. Eugene Coste and others. This view was also maintained by the Norwegian geologists as accounting best for the origin of the Norway phosphates which there occur in almost identical rocks and under similar conditions to those found in Canada. The discussion of the several views of the different authorities on this point will be found in "Mineral Resources of Quebec," published in the Report of the Geological Survey, 1888-89, and need not here be repeated.

Organic as opposed to igneous.

Dr. Hunt's views quoted.

In the Geology of Canada, 1863, Dr. Hunt, in describing the presence of apatite in the rocks of North Elmsley and Burgess, in Ontario, says that "the mineral is found in beds of limestone in the form of grains and crystals", but subsequently in 1866, states that it also occurs in veins. In regard to its presence in the limestones he makes the statement, on page 188, in describing the so called vein structure, that "I have described localities of crystallized apatite as occurring in beds of limestone in Burgess, where a subsequent examination, (while confirming the existence of the mineral in the limestone beds of that region) has shown nevertheless that the workable deposits are, with few, if any, exceptions confined to the veinstones. From a lithological point of view, there cannot be any objection to extending the name of limestone to these calcareous veinstones, but geologically, it becomes important to discriminate between them and those great masses of limestone which are sedimentary deposits". It will thus be seen that Dr. Hunt at that date recognized clearly the true distinction

between the calcite associated with the pyroxene and the limestone of the gneiss formation.

In this connection, Mr. J. Fraser Torrance, M.E. in the Report for 1882-83, in speaking of the presence of the apatite in the area west of the Lièvre river, regards the mineral as occurring as irregular segregations in the country rock, and as confined to one or more zones which follow approximately the course of the Lièvre, in a generally north-west direction. He states that the rock is more or less impregnated with the mineral; and from a close study of the several mines throughout the district over a large area, concludes that the statement of Hunt in regard to the nature of these deposits, viz., that they are divisible into two classes, as bed and fissure veins, is correct if we use the term bed in a sufficiently broad sense, but the majority of the deposits are very irregular segregations from the phosphate bearing country rock, which is generally a massive pyroxenite. As deposits are found in a certain bed which is more or less richly impregnated with phosphate and may sometimes be traced for a considerable distance, such deposits may be said to be merely a bed of phosphate of irregular richness. Exception is taken to this kind of classification as misleading, since it seems to imply the submarine origin of these deposits; whereas the origin of these pyroxenic rocks may possibly be due to contemporancous intrusion. M. J. Fraser Tarrance.

Later, in the Report for 1887-88, Mr. Eugene Coste, in discussing the origin of the iron ores and apatites of the Ontario and Quebec districts, accentuates this intrusive character much more strongly. He declared strongly for the eruptive nature of the apatite bearing rocks in Canada, and held that the apatite occurs as the result of emanations which have accompanied or immediately followed the intrusion through the country rock of the several districts of many kinds of igneous rocks which are no doubt the equivalents of the volcanic rocks of to-day. He holds that these mineral deposits as well as the intrusives are deep seated in their origin, and that the fears often entertained by miners of phosphate, that their deposits are mere surface pockets, are not well founded. He says "if this origin is understood it will facilitate and encourage the working of these deposits in depth, because the accompanying igneous rock, forming a mass or dyke alongside the deposit, will be easy to follow, and because if it is apatite or iron bearing at the surface, it will always be a guarantee that it will also be in depth, as each separate mass of igneous rock is generally constant in composition". It may be here remarked that this contention of Mr. Coste's has been borne out in several of the deep mines of the Templeton and Buckingham districts. Mr. Eugène Coste.

Later, in the Report for 1890-91, after a careful examination of the apatite areas, Mr. E. D. Ingall came to the conclusion that the pyroxenite which carries the apatite and is associated with gneiss, granite, &c., is apparently intrusive in the gneissoid rocks, and all the phosphate deposits of importance occur in it.

Mr. E. D. Ingall.

He further says that "the phosphate bodies are distributed through these belts in the most irregular manner, each one varying from the other in the details of its characteristics, showing in common, however the features of extreme irregularity. In a few instances they show a general extension of the phosphate in a plane which gives the openings made on them the appearance of having followed a vein, but there are no walls or sharp planes of division which persist for any distance between the phosphate and enclosing rock. Most of the excavations made, show the bodies of mineral to have been of extremely irregular shape; merging into the enclosing rock and holding a very varying proportion of intermixed rock. At places very large bodies of almost pure phosphate have been encountered, yielding many thousand tons".

Prof. A. Osann.

Of still later date is the report by Prof. A. Osann of Germany, who in 1899, made a somewhat exhaustive study of the occurrences of apatite, mica and graphite in the district north of Ottawa. In his report for the year 1899, Vol. XII, he clearly shows that the large pyroxene masses of the Lièvre district are intrusive in their nature, see pp. 17-27. That where the smaller pyroxene processes penetrate the country rock they sometimes assume the form of veins, but that all the occurrences of rock and mineral are of later date than the rocks which they penetrate, and by inference that the contained apatite, while sometimes occurring in vein form as in the Gatineau district, and in some of the Templeton mines, and as pockets of large extent as on the Lièvre, is not of organic origin; and from the weight of evidence collected during the last fifteen years it may safely be asserted that the view once maintained as to the sedimentary nature of the apatite bearing pyroxenes has been very clearly disproved, not only from their study in the field but by their examination under the microscope, and that it is now generally admitted that they belong to the class of igneous and intrusive rocks.

Mode of occurrence.

The determination of the mode of occurrence and origin of the apatite deposits is of great importance as regards the probable profitable development of the mines at different centres. Thus as regards the presence of the mineral in the crystalline form it is clearly shown that it is found not in beds of limestone proper but in calcite masses

in the pyroxene which have been loosely called limestone by many mining experts. So also as regards its presence, as sometimes stated, in the gneiss where the pyroxene is found in small quantities disseminated through portions of the ordinary greyish variety, no apatite has ever been found unless as mere indications. As regards the occurrence of the limestones themselves, while now universally considered as a portion of the altered sedimentary rocks of the Grenville series, various other opinions have been held from time to time by eminent authorities some maintaining that all the calcareous bodies are of similar origin and aqueous in their nature, while others, many years ago, including Emmons, Mather, &c., came to the conclusion that the crystalline limestones themselves were to be accounted for as really igneous rocks.

Whether these deposits are found as beds or veins has long formed a subject for discussion by many writers. The investigations made in 1892-93 by the writer led to certain conclusions which may here be briefly stated.

Formerly many of the apatite bearing dykes of pyroxene were regarded as true veins though their occurrence as traversing the crystalline rocks, gneiss or limestone was clearly pointed out; so that it became the custom for some years, in describing the presence of the mineral, to assign its position as occurring either in the form of true veins or beds only. Of the former kind its presence in small dykes of pyroxene where it is always found in or near the edge of contact with the enclosing gneiss, was so regarded, as also the cases where it is found in connection with calcite which formed the outer portion of these pyroxene masses in many places. Where the mineral occurred in connection with the larger masses of the pyroxene sometimes in deposits of great extent following along irregular lines, such occurrence was held to pertain to the bed type, on the supposition that all the containing rocks were true bedded strata and formed an integral part of the gneiss and limestone formation. Igneous nature of pyroxenite.

From the manner in which the pyroxene occurs when in large areas, as is often the case in the mines along the Lièvre river, this theory as to its bedded character does not hold, as has already been indicated from the statements of others already quoted. In many places the associated rocks are displaced to a considerable extent; in other cases the mass of the pyroxene, as seen at a number of openings, has not reached the surface but appears to have pushed up the overlying gneiss or quartzite, forming a dome-shaped structure of clearly intrusive matter in which the apatite occurs.

As to the vein character of the smaller dykes which are often clearly side spurs from the larger masses, following rents made in the overlying strata, traversing these in all directions, and clearly connected with these larger intrusive bodies, it is not yet sufficiently evident why these should be classed as veins instead of spur dykes.

Vein character of deposits.

As for the vein-like nature of the many deposits which occur with calcite, and which hold crystals of apatite, mica, pyroxene and other minerals, it may be said that these present many of the features of true veins, and have been so regarded by Osann and by other recent observers of the district, and the several minerals apparently owe their presence to segregation agencies. The calcite is evidently the matrix or filling in which the crystals are embedded, but in a number of cases this calcite gives place to apatite through which the mica and pyroxene crystals are scattered. In this case however there are no well defined foot or hanging walls, the latter being a sharp contact with gneiss, while the former is formed by the body of the pyroxene itself through which for a short distance the crystals of the several minerals are disseminated. This feature is also found in connection with other mineral occurrences, such as the actinolite deposits of Elzevir township in Ontario, where along faulted contacts between the diorites which sometimes hold the mineral, and the underlying hornblende rocks, asbestiform crystals are disseminated in the foot wall to a depth of several inches.

Association of apatite and mica.

In Canada the apatite is usually closely associated with mica, and in the early days of the mining industry the mica was removed and went to the dump as a practically waste product, many hundreds of tons in this way being lost to commerce. This was to some extent due at that time to lack of market and to the consequent small value attached to the mica. At the present time many of these old phosphate mines have been converted into mica mines, and the former is now saved as a by-product, and being extracted at a small cost is claimed to be sold at a profit even at the present low prices obtainable. At a number of the mica mines, however, no apatite occurs, or at least in such small quantities as to be of but small economic importance.

In actual mining it was frequently found that the apatite was of but small economic value when it occurred in the vein form with calcite and mica, since the amount of the mineral present, even in the crystalline form, was insufficient to repay the actual cost of its extraction by itself. The great economic deposits of the mineral are those in which the apatite is found in large pockety masses, often without much mica being present. In such cases the extraction when properly

Pockety character.

conducted was made at a comparatively small cost and at the prices which prevailed some twenty years ago produced a large margin of profit. Such deposits sometimes continued downward to a great distance and even at a depth of over 600 feet, as at the North Star mine, there appeared to but little change as to production.

Deep mining.

In the case of these deep mines it is practically impossible to say where such deposits would terminate since the conditions which have affected its occurrence in the upper workings are similar throughout, the apatite being found along the margins of the intrusive dyke, in which it appears to have been deposited through the action of acids which have ascended along the course of the dyke and have impregnated the pyroxene along the zone of contact. The presence of the mineral in such cases is often similar along both margins of the intrusion.

Mr. Burley Smith quoted.

In some, in fact in the majority of the mines examined in the Lièvre district, the presence of the mineral seems to be assocaited with later intrusions of diabase which traverse the pyroxene. One of the best illustrations of this peculiarity is seen at the old Etna mine workings where a shaft was sunk along the south side of one of these diabase dykes to a depth of nearly 200 feet in a mass of apatite which was followed down with the diabase as a foot wall. In places large deposits of pyrite were found in the base of the apatite, and the action of the newer intrusion was evidenced at many points by the alteration of the adjacent rocks. In connection with this feature Mr. Burley Smith, the manager of these mines, remarks that " whatever may have been the origin of the apatite and how it came there, there is no question that the ore is found only in and accompanying the pyroxene, which according to the best authorities are immense dykes intruding through the stratified gneiss to the surface, not always however coming quite to the surface but sometimes covered with a cap-rock. Experience shows that it is useless to look for apatite away from these conditions."

" The deposits having the appearance and many marked characters of pockety veins cannot be called true fissure veins, but having these characteristics they can and should be sought and mined for on a system applicable to vein mining. They have often walls corresponding to the foot and hanging walls of true fissure veins. Their direction is not uniform but generally N.E. and S.W., varying some degrees, but a group of these deposits appear to always run parallel to the same axis, having also the same inclination, and though the so-called veins may alternate from wide bunches to tiny strings they never quite give out and may sometime be traced for a very long distance."

"Again they are traversed by dykes of evidently much more recent intrusion than the pyroxene dykes, cutting right up through them to the surface where they present the appearance of hogs-backs. At these points the vein-like deposits are thrown to one side or the other forming as it were cross courses, often widening out at the junction into considerable pockets. Perhaps the strongest feature is that the so-called vein will often continue to follow the face of the cross dyke for a considerable distance laterally and frequently right up to the surface. I am quite unable to account for this unless it has been by the refusion caused by the igneous effect of the last intrusion, the great number of apatite and pyroxene crystals near the surface strongly favouring this view, together with the burnt appearance of the rocks at the surface." Can. Mining Review, March, 1893, p. 43.

A somewhat close study was made by the writer in 1892-93 of all the known occurrences of apatite of commercial importance, north of the Ottawa; and from this certain facts then observed may be stated. Outside of the area in Quebec, enclosed by the Gatineau and Lièvre rivers, and the deposits in Portland east, no deposits of economic importance were observed beyond a distance of twenty-five to thirty miles north of the Ottawa.

East of the Lièvre river the principal mining areas are found as follows:—

Areas east of Lièvre river.

TOWNSHIP OF BUCKINGHAM.

Range XII, lots 17 and 18, the Squaw Hill and Aetna.

" XII, lot 19, the Emerald.

" XI, lot 19, the Washington or Lansdowne mine.

IN THE TOWNSHIP OF PORTLAND EAST.

Range I, lot 6, the Little Rapids mine, (formerly Watts)

" II, lot 3, the Fowler and Bacon mines.

" II, lot, 8, the London mine, nearest the Lièvre.

" II, lots 2 and 13, owned by the Compagnie Française des Phospbates du Canada.

" II, lot 7, the London mine.

" III, lots 1 and 2, owned by the French Co.

" IV, S. ½ lot 1, west ½ lot 2, French Co.

Range IV, E. ½ lot 2, the Glasgow mine.

" V, E. ½ lot 9, French Co.

" V, lot 13, the Mallette mine,

" V, lot 7, The Tamo Lake mine.

" VI, lots 7, 8, 9, 10, The French Co.

" VI, " 16, 17, 18, Chapleau's, the mine on 18.

" VI, " 2, River front, The Salette mine.

" VII, lots 7, 8, 9, 10, The French Co.

" VII, lot 16, 17, The Sweetland mine.

" VII, " 18, The North Star mine. (Haycocks).

" VII, " 24, The Croft mine.

" VIII, lots 9, 10, 11, 12, 16, 17, The French Co.

" VIII, " 26, The Philadelphia mine.

" VIII, " 27, The McLaren mine. (Camerons).

" IX, lots 9, S ½ 16, 17, 18, 19, 20, The French Co.

In this group are some very important mines, including the Little Rapids, the Emerald, Squaw Hill, and Aetna, the North Star the French Co's mine on range II, and the London mine.

## PORTLAND WEST.

Areas west of Lièvre river.

In the township of Portland west on the west side of the Lièvre are located some of the largest and most productive mines of the district, among which may be mentioned the following:—The areas being taken from the manuscript map of the district prepared by Mr. E. D. Ingall and Mr. James White.

Ross Mountain mines, lots 5, 6, range VI; 1, 2, VII, River front.

Crown Hill mines, lots 3, 4, range VII, River front.

High Rock mines, lots 5, 6, range VII, River front; lots 7, 8 range VII; and lots 1, 2, range VIII.

Canada Phosphate Co., Star Hill mine, lots 3, 4, range VIII, River front, lots 7, 8, 9, same range, lots 7, 8, range IX.

Chapleau mine, lot 5, range VIII, River front.

Dugway mine, lot 9, range VIII.

Central Lake mines, lots 7, 8, 9, 10, range X.

TOWNSHIP OF BOWMAN.

High Falls mines, lots 1, 2, 3, 4, range IV.

As the conditions regarding the occurrence of the apatite can be well studied at this group of mines and were carefully investigated during their development, a short statement of certain points then observed may be of interest as viewed from the geological standpoint, and as illustrating some of the views already briefly stated as to the actual occurrence of the apatite, and its relation to the containing rock masses.

The country rock throughout consists of greyish, sometimes reddish gneiss with quartzite, and occasionally thin bands of crystalline limestone. The generally regular strike of these rocks throughout the area has been frequently disturbed through the agency of the intrusive masses of gabbro or pyroxenic diorite which is sometimes seen in large masses, in places with a capping of the gneiss, such contacts being well exposed in several of the large pits.

### CROWN HILL.

Crown Hill mine.

At the Crown Hill, the gneiss and quartzite are in places quite rusty from the presence of quantities of pyrite which have been developed along or near the contact of the pyroxene or of the pegmatite dykes. The quartz of the latter, which with a generally white felspar makes up the mass of the dyke, is often of a peculiar lilac blue tint. The apatite is found in the pyroxene, which does not follow the lines of stratification of the gneiss, either as small irregular pockets near the hard granite, or in some cases along jointing planes. Some of the intrusive rock has the aspect of anorthosite without gneissic structure.

In a couple of pits which are situated about midway up the slope of the hill on the south east side in a mass of pyroxenic diorite, which has burst through and displaced the gneiss in contact, there is a cross dyke of diabase and the apatite is found near the contact of this with the pyroxene rock.

In a third pit near the crest of the hill a well defined vein-like occurrence of apatite is presented in the pyroxene with a course of N. 25 E. It cuts across hornblende gneiss and is associated with a green pyroxenic diorite or gabbro, and in the upper part with a two foot dyke of the peculiar diorite known as concretionary or "Leopard rock". This weathers a dirty white and shows well the concretionary structure

on the weathered surfaces. The apatite sends off small spur-like veins from the sides of the main deposit which has a thickness in places of 12 to 14 inches. Near the crest of the hill the apatite-bearing band is apparently cut out between the diorite and the "Leopard rock". The quartzite and banded gneiss in the vicinity has a strike of N. 75° W. vertical.

### ROSS MOUNTAIN MINE.

At the summit of the hill at the Ross Mountain mine, the plant of which was removed some years ago, a deep pit was sunk in a rock composed of felspar and the bluish quartz, which cut the pyroxene, and from along the contact a large amount of pockety apatite was extracted. Here a small mass of calcite occurred in the pyroxene in which were masses of crystals of apatite and pyroxene but there are no beds of true limestone nor any stratification visible in these rocks. About 75 yards south of the old engine house the rocks are regularly banded gneiss and quartzite free of diorite intrusions and showing no trace of apatite. Ross Mountain mine.

In a second pit of the Ross mine east of the engine house, sunk in a hard dark-grey pyroxene which presents the aspect of a true intrusive mass and is well jointed in places, the apatite occurred in a series of pockets which yielded a large amount of the mineral. Just west of the pit the gneiss and quartzite strikes N. 15° E., with a high dip to the south, and this is cut by small diorite dykes which follow the planes of stratification.

One hundred and fifty yards north of this the apatite occurred in chimney form in a hard greenish pyroxene which carried the mineral in detached pockets without any indication of bedded or vein structure. Similar pockety occurrences were seen on the north-west side of the hill towards High Rock in an opening about 100 feet long. Here the gneiss strikes N. 60° W. vertical, the dip of the pyroxene dyke is S. W. $<70°$.

At the west pit of the Crown Hill mine near the end of the old track, a large pit was sunk in a mass of pyroxene which was cut by pegmatite. The pyroxene cuts across the gneiss which strikes N. 60° W. vertical, while the course of the dyke is N. and S. with a dip to the east of 60 degrees. The pyroxene is a hard dirty-green dioritic looking rock. Crossing the ridge to the old track the gneiss is rusty and is cut by pyroxene and pegmatite and in the former are the usual pockety occurrences. The gneiss, which has a N W. strike, is pushed

off to the south-west as if by the intrusive mass, and the apatite impregnates the pyroxene to a distance of 8 to 10 feet from the line of contact. The occurrences of apatite in detached pockets are frequent at a number of pits in this area and the gneiss is frequently very rusty from the pyrites which accompanies the contact. The presence of the apatite is often first indicated by small patches of the mineral which sometimes swell out into large masses yielding many hundreds of tons, but sometimes these are cut off abruptly as if by faults.

Near the summit of the hill at this mine, two pits were carefully examined. The gneiss strikes N. 70° W. with a south-west dip, and at the pits is cut off abruptly by a dyke of white pegmatite which intersects a mass of dark pyroxenic diorite. Both these are cut by a three foot dyke of fine-grained blackish diabase, of evidently later date, and the apatite occurs here in the form of chimney-like pockets connected by a small vein of the mineral. In the dumps small patches of the apatite are seen attached both to the pyroxene and to the pegmatite, but is rarely seen in the gneiss, so that the apatite would appear to have followed the intrusion of the granite through the pyroxene.

On a road leading up from Crown Hill to High Rock, the gneiss and quartzite are well banded with a strike of N. 40° W. and a south-west dip of 75 degrees. They are cut off squarely across the strike by a dyke of white pegmatite holding purple quartz, and a fourth of a mile south-east of the engine house the dip is reversed to N. 65° E. indicating an anticlinal along which the contorted character of the beds is admirably seen. On the road west, and at the Dugway mine, the same occurrences of gneiss, pyroxene and pegmatite are visible; and at the mine itself the gneiss is locally deflected where the pyroxene is largely developed.

### STAR HILL MINE.

Star Hill mine.

At this mine the main pit is sunk in a heavy dyke of green pyroxenic diorite, cut by white and red granite dykes. There is no gneiss visible at the pit itself and the apatite occurs as a vein or fissure deposit near the granite contact. A short distance north of the pit the gneiss and quartzite are very rusty, and where the diorite crosses, is much twisted and broken, with spurs leading off from the main dyke. Much of the gneiss is garnetiferous and is cut across the strike by the pyroxene mass and by the pegmatite.

A second pit shows the run of the pockety masses of apatite to follow closely along the strike of the gneiss, the pyroxene coming to

the surface along the lines of banding, and the apatite is near the contact in the pyroxene. Similar occurrences are seen in the more northerly pits where also the pyroxene is cut across by the pegmatite. It would seem from so many illustrations of this mode of occurrence of the apatite, near the intersecting granite, that the presence of the mineral is to a large extent due to the agency of the later intrusion.

### HIGH ROCK MINE.

High rock mine.

This mine is situated on the crest of a hill, about 600 feet above the river and was connected with the landing stage by a tramway, nearly two miles long built down the eastern slope. The country rock is for the most part the ordinary rusty gneiss and quartzite, with a general strike of N. 65° W. and a south-west dip. At the crest of the hill, the pyroxene has a very large development, through which pegmatite intrusions are numerous and sometimes of large size. The apatite has been developed, not only along the crest of the ridge but is also found in large pockety masses well down the side, being opened as far down as 400 feet from the top, where it is well exposed in a series of pits and trenches, especially along the south-west side of the hill. Here it is found along the south side of a heavy dyke of dolorite which forms a foot wall for the deposits, so that the apatite appears to owe its presence to this later intrusion. The apatite occurs in immense pockets and of fine quality. Similar occurrences are noted at a number of the pits on the crest of the hill and along the west slope, where sometimes the pyroxene mass shows a capping of the gneiss which appears to have been thrust upward by the intrusive agency.

In fact it would appear that in the area between Chalifoux's landing to the south-east of Ross mountain as far north as the High Falls mine, a distance of some five miles, there is a remarkable development of the pyroxene which, while not continuous throughout, shows its presence in large masses at many points.

### CENTRAL LAKE MINE.

Central Lake mine.

The next mine going north is known as the Central Lake area. Here also the ordinary country rock is gneiss and quartzite, with which occur bands of crystalline limestone, which show a short distance to the east of the workings. The strike of the rocks here is about north and south and the dip west 75 degrees. The pyroxene at the several pits carries mica as well as apatite, and at one of the pits the pyroxene is cut by a white pegmatite dyke which in turn is cut by a heavy dyke

of dark gray diabase. In several of the pits the mica and apatite are closely associated along the contact of one of the dykes, and these occur with local thickenings which have been excavated in chimney form to a considerable depth. These pockets thin out at the sides and show small stringers as side spurs or dykes, on either side of the excavations.

A third pit at this place is sunk in a heavy mass of greyish pyroxene which cuts a rusty hornblendic and quartzose gneiss, the edges of which have been bent upward along the side of the dyke for several feet, the apatite occurring close to the contact in the form of chimney-like pockets, with thin bands of pyroxene at each side along the contact zone. It would seem in such cases that the apatite owes its presence to deep-seated agencies.

### HIGH FALLS MINE.

High Falls mine.

The most northerly of the mines of the group is known as the High Falls. The country rock is the usual rusty gneiss and quartzite with a considerable development of crystalline limestone to the east in the direction of the Liévre river. The usual presence of the pyroxene in large masses is here seen with intersections of the pegmatite as at the other mines already described. At the mine itself, which is on the east side of the ridge about a mile west of the river, the rock is a dark pyroxenic diorite like that at High Rock, and the apatite occurs in detached chimney-like pockets. At the most northerly pit the gneiss strikes N. 40° E. and dips S.E. $<$ 70°. The apatite at this place does not follow the run of the gneiss, but in this and in other pits to the south west the excavations have a course of N. 25° W., the roof sloping to the west at an angle of 15 degrees. Towards a lake known as Bowman's, there is an intrusive mass of purple grey colour resembling anorthosite which cuts the pyroxene, and the gneiss does not appear. Portions of the dyke are rusty, and the apatite occurs in chimney-form, at one place extending into the hill for about 20 feet but downward to an unknown depth. The apatite occurs as usual in the greyish-green pyroxene in close proximity to the other intrusive mass. There is no indications of any bedded structure either in the pyroxene or in the apatite, or of a vein structure in the latter, and on the sides of some of the pits small quantities of apatite are attached to the mass of the pyroxene showing the rock to be impregnated quite extensively at several places.

## NORTH STAR MINE.

Among other interesting places where the apatite deposits can be well studied may be specially mentioned the North Star mine on the east side of the Lièvre. Here the mining has been carried on principally on or near the crest of the ridge at an elevation of about 600 feet above the river which is four miles to the west. As the depth of the deepest shaft is in the vicinity of 600 feet the bottom of the workings are about at the river level. North Star mine.

The country rock is a reddish and sometimes greyish gneiss, with a strike of N. 15° W. and an east dip of sixty degrees. This is traversed by dykes of several kinds. At the south end of the area an opening has been made in a mass of greyish pyroxene in which a little apatite is visible. Further north a large vein-like, in places pockety, deposit is seen in the pyroxene with a north-west course going down nearly vertical, and the gneiss in the vicinity is much intersected by granite dykes.

Ascending the hill northerly towards the hoisting plant, the strike of the red and grey gneiss changes to north and south, with a high east dip, and a pit is seen where in the excavation the pyroxene occurs as a round chimney-like mass about 10 feet in diameter, the banding of the gneiss following closely around the mass of the intrusive rock, on all sides. The apatite occurs along the outer zone. Just to the east of this another dyke of pyroxene breaks through the gneiss along the line of stratification or banding and this carries small quantities of apatite with red calcite. The gneiss in contact is much shattered and carries pyrite. No apatite is seen in the gneiss, but it occurs with crystals of mica and pyroxene along the contact in the calc . Dykes of pegmatite cut across the pyroxene. At the pit under the hoisting shed the crystals of mica seemed to follow more closely the smaller pegmatite dykes along the line of their intersection with the pyroxene.

At the principal opening of the North Star, which has a length of about 130 feet and a depth of over 300 feet, an interesting exhibit of apatite is disclosed. Three large pockets in the form of chimneys are seen which are connected by small stringers. This is near the crest of the ridge, and the apatite is continuous to the bottom of the shaft which is sunk in the mass of the pyroxene throughout. The mineral occurs near the contact with the gneiss on both sides of the main dyke but is very irregularly distributed at different point, sometimes occurring in immense pockets, while the connecting portions are often reduced to small strings. This condition of development appears to

prevail throughout. At the north pit the structure is a dome-like mass of the pyroxenic diorite which carries the apatite more or less disseminated, the pyroxene having the aspect of an intrusive body which has burst through the surrounding gneiss and tilted the latter from it in both directions. A similar structure is visible in several other pits, independent of the main mass of the pyroxene. In some of the smaller pits the apatite is associated with crystal of dark mica. Along a series of pits still further north a similar displacement of the enclosing gneiss can be seen. In places where the apatite is found in large bodies side spurs of the mineral are given off on either side, so that the conditions of its occurrence appear to very similar throughout the entire extent of the pyroxene development. Mica crystals are developed in the apatite near the outer contact, similar to occurrences of this mineral in calcite in the Gatineau district.

### SALETTE MINE.

Salette mine.

In this mine which is near the Lièvre river, the quartzite and gneiss are cut by green pyroxene and this in turn by white pegmatite, and the presence of the apatite is near the contact of the two intrusions.

### LITTLE RAPIDS MINE.

Little Rapids mine.

Of a somewhat different type from the North Star mine is the Little Rapids mine, which is about one mile east of the Lièvre river at the locks about 12 miles above Buckingham village. This was one of the first mines opened in the district, and mining was carried on by Mr. W. A. Allan in 1883, and continued for some years.

The country rock is the ordinary greyish and quartose gneiss which extends from the river shore eastward, and is cut by numerous dykes of diorite and granite. Where comparatively undisturbed the gneiss has strike of N. 40° E. with a N. W. dip of 50°. The pyroxene dyke in which the mine is located is large and has a direction of N. 10° E. with a dip to the east of 80 degrees. The width of the apatite bearing position of the dyke, which is near the contact with the gneiss, is from three to five feet, and crystals of mica are developed in the lower portion near the pyroxene contact of this zone. The west side of the cutting shows a wall formed of the banded edges of the gneiss and quartzite, and in the mass of the dyke are pieces of the gneiss which appear to have been caught up in the outflow. Dykes of pegmatite cut the gneiss and the pyroxene, several other dykes of the latter

occurring in the vicinity, in most of which the apatite is found. The workings reached a depth of about 220 feet, and the yield of apatite was large, the deposit like that of other places varying in thickness at different parts of the mine.

At the upper London mine which li s to the north of this, a similar occurrence of pyroxene and pegmatite dykes cutting and altering the gneiss is seen, the strata of the latter being bent over and displaced along the contact with the development of pyrite in many places* along the margin. The apatite occurs as a contact deposit near the contact of the pyroxene and the gneiss. A similar occurrence of sharp definition between the pyrozene and gneiss is seen in the other London mine which is on the side of the ridge near the Lièvre, and in the open cutting at this place the presence of the apatite near the contact can be well studied.

### THE AETNA, SQUAW HILL AND EMERALD

Aetna Squaw Hill and Emerald mines.

These three mines form a small group near the Lièvre river which when worked were among the largest and most important in the district. They occur near the crest of a ridge in which the development of the pyroxene and other intrusive rocks are largely displayed. The apatite frequently occurs at the intersection of the later dykes with the pyroxene, and frequently a considerable development of pink calcite is seen in the latter in which the apatite is found with mica crystals. The large development of apatite here is probably, as at the group of mines on the west side of the river at High Rock, etc., due to the presence of the intrusive masses. The shaft at the Aetna reached a dedth of 130 feet in 1893, or at about the close of the industry in this area. The apatite is often found along the course of some one of the diabase dykes which forms a foot wall and carries masses of pyrite near the contact with the pyroxene, and occasional very large crystals of apatite were here found. The name of "Crystal pit" was given to one of the principal excavations from the fact that the pit was at first sunk on the mass of the crystal itself for some feet. Similar modes of occurrence are seen at several of the other mines in this vicinity.

Glasgow mine.

At the Glasgow mine a shaft said to have a depth of 300 feet was sunk in pyroxene near the contact with the gneiss on a body of apatite with a reported thickness of five to six feet. Small quantities of pink calcite occur at intervals through which mica is disseminated with apatite and pyroxene crystals. The intrusive dykes are numerous, and intersect the gneiss in all directions and the apatite is usually found in l aches or pockets in these as elsewhere.

Philadelphia mine.

At the Philadelphia mine the cross contact of the pyroxene with the gneiss can be well seen, the course of the former being N. 40° E. with a dip S. E. 35°, while the strike of the gneiss is N. 20° W. with a N. W. dip, the intersection of the dyke with the gneiss being at an angle of about 60 degrees. Both red and green apatite are found in this as at several of the other mines in the district.

McLaren mine.

At the McLaren mine adjoining to the west, the gneiss is nearly flat as if thrust up and overlying a mass of pyroxene which is in turn cut by red pegmatite, in which the felspar has a purple tint. No mica was seen at this place.

From the above descriptions of some of the leading apatite deposits of the Liêvre, which might if necessary be greatly extended, the following conclusions may be reached.

Mode of occurrence of apatite.

1st. Where apatite occurs in large masses of pyroxene, which has been shown to be clearly an intrusive rock in the gneiss, and where this is cut by later dykes of pegmatite or diabase, the presence of the apatite is in close relationship to the occurrence of the later intrusion.

2nd. In the case of many of the smaller dykes of pyroxene the apatite occurs near the outer zone or in contact with the surrounding gneiss and is sometimes associated with mica and calcite, though not always so. In these cases the apatite frequently assumes the crystalline form, and the conditions approach those seen in many of the mica mines of Templeton and Hull.

3rd. The indications of the intrusive nature of the pyroxene in the gneiss, and of the later intrusions of diabase and pegmatite both red and white, are so clear as to warrant the assertion that when apatite is found in these rocks its presence is not due to organic agencies but to conditions belonging to the period of intrusive action.

Priest Creek mine.

To the north of the apatite belt already described there are several localities, such as the Priest Creek areas, in which apatite is found at several points and attempts have been made in former years to work some of these deposits. Apparently no great amount of success attended such efforts, and the present depressed condition of the industry, together with the distance from a convenient shipping point has interferred with their practical development. From the report by Mr. Obalski, for 1889-90, it will be seen that the mineral has been recognized in this direction in the townships of Bowman, Bigelow, Denholm, Derry, Hincks, Lochaber, McGill, Villeneuve and Wells, but practically no attempt has ever been made to ascertain the amount of mineral at most of these localities.

## The Templeton District.

The apatite mines of the Templeton district present certain features differing somewhat from those which have just been described. The country rocks are however practically the same, but in portions of the field there is a greater development of the crystalline limestones. Pyroxene dykes, often of large size, with others of pegmatite and diabase, are common. Templeton areas.

One of the features here seen is the occurrence of the apatite with a large development of mica crystals. In some of the largest mines, notably in the Blackburn, which for years was the largest producer in the district, this feature is especially well seen, and since the closing of the mine as a producer of apatite it has been regularly operated as a mica mine. In this respect the occurrences of these minerals more nearly resemble the conditions which are seen in the mines along the Gatineau river and throughout the mines in eastern Ontario.

In the Templeton district during the period of apatite mining, the principal mining areas comprised the following :— List of areas in Templeton

The Blackburn, lot 10, range XI, Templeton township. In addition this mining area included lots 7, 8, 9 and 11, same range.

The McLaren, lot 8, range XII ; S. ½ 7, N. ½ 10, range XI ; and N. ½ lots 4, 5, 6, range VII.

Lomer, Rohr & Co., largely engaged in milling rather than in mining directly.

Jackson Rae Phosphate Co., W. ½ lot 9, range X.

Canada Industrial Co. (C. Lionais & Co.) lot 16 range IX ; E. ½ lot 9, range X. (Post Mine) Société Française ; lot 3, range XIII, in addition to large areas in the Lièvre district.

Anglo-Canadian Co., lots 6, 7, range XIII (Battle Lake mines) ; and lots 9, 41, 42, 43, 44, 45, 56, Templeton Gore.

Templeton and Blanche river Co., lot 6, range XI.

The Grier area, S. ½ lot 3, S. ½ 4, and 7, range VII ; lot 7, range X.

Miller mine, S. ½ lot 2, range XII.

Murphy mine, S. ½ lot 12, and lot 6, Gore.

Several of these mines were opened at various dates ranging from 1880 to 1886. From some of these the output was quite large for several years but gradually decreased. The greater number of these belong to the class known as contact deposits, usually associated with

mica and calcite, the apatite often occurring in the form of crystals; but in some cases, notably in the Blackburn mine, the calcite is largely replaced by apatite through which the mica crystals are disseminated, and the ore body is in places very large. The occurrences are on the whole different from what is seen along the west side of the Lièvre, in that the masses of pyroxene are usually much smaller, and there is not the same close association of the apatite with the newer diabase or granite dykes.

### WAKEFIELD AND HULL MINES.

Wakefield and Hull areas.

In the southern portion of the township of Wakefield especially in ranges I and III, occurrences of apatite are frequent and have been worked quite extensively. Among the principal deposits are several in the vicinity of Wilson's Corner, all of which may be classed as contact deposits, the mineral occurring for the most part with mica and calcite.

Mines in Wakefield township.

Among these mines may be mentioned:—

Haldane's mine, lot 12, range I.

Moore's mines, lot 17, range I, and lot 18, range II.

Wilson's mine, lot 17, range II.

Gemmill mine, lots 23, 24, range V.

Harris mine, lot 30, range IX.

Seybold mine, lot 18, range II.

Other mines in this district which have been opened and worked for mica to some extent show also the presence of apatite occurring in the crystalline form in calcite.

Mines in Hull township.

In the township of Hull, apatite deposits are found at many places, usually associated with mica in the same manner as the occurrences in Wakefield. Among the most important of these may be mentioned the following, which for some part of their history were mined for apatite and partly for mica.

The Scott mine, lot 15, range X.

Prudhomme mine, lot 9, range XII.

Davies mine, lot 9, range XI.

Gow mine, lot 10, range XII.

McLennan mine S $\frac{1}{2}$, lot 10, range XIV.

Barbers mine, lot 16, range XVI.

Browns, and Fortin-Gravel mines, the former on lot 19 range VII, the latter on lot 18.

Haycock mine, lot 17, range X.

Connor mine, lot 14, range XI.

Snow mine, lot 14, range XII.

These are all on the west side of the Gatineau river.

On the east side in Hull township may be mentioned :—

Wilson mine, lot 13, range XVI.

Chubbuck mine, lot 12, range XV.

Burke mine, lot I, range XIII.

Vavasour or Gemmill mine, lot 10, range XII.

Webster mine, lot 10, range XIV.

Apatite with mica and calcite.

From an examination of many openings made in these townships, from some of which considerable quantities of apatite were taken in the earlier years of the industry, it may be stated that, for the most part, the mineral occurs in the crystalline form associated with mica crystals in calcite near the contact of the pyroxene with the gneiss. Occasionally the apatite is found as pockety masses in the pyroxene itself as in the Lièvre district, but the size of such pockets is nowhere so important as in that area.

From the economic standpoint it may be questioned whether the mining of apatite from mines of this class can ever be permanently profitable. The amount of calcite and other rock which forms the vein filling necessary to be extracted to obtain merchantable apatite in quantity is large, and in so far as the exploitation of these deposits proceeded some twenty years ago, it was found that only the largest of these could be mined to profitable advantage. Many of them were opened by shallow pits and abandoned, others reached depths along the calcite filling of 150 to 200 feet, drifts being carried along the run of the pyroxene, but all were long since abandoned. Several were mined subsequently for mica, and in some cases this is still pursued as in the case of the Vavasour mine and others, in which case the apatite extracted with the mica is saved and sold as a by-product.

In some of the mines along the Gatineau which are opened on large masses of pyroxene as at the Cascades, the Nellie and Blanche, the Cassidy mine, &c., while mica has been found in large pockets occurring thus after the manner of the apatite pockets along the Lièvre, but small indications of apatite itself have been found. The

reason for this is not quite clear, since there is frequently the same occurrences of diabase and granite dykes in both areas. Usually however at all the mining areas in the Templeton and Gatineau districts the two minerals, mica and apatite are closely associated.

Output for these areas.

While the total figures of the output from the different mining centres north of Ottawa are not available for publication as regards the different mines, it is clear that, by far the great bulk of the output for the fifteen years for which mining returns are furnished came from the large group of mines in the Lièvre district, and that the only truly large producer outside this area was the Blackburn mine in Templeton. The output from the Hull and Wakefield areas aggregated but a few thousand tons as compared with the total recorded output for the Quebec mines of 270,000 tons between the years 1878 and 1894 both inclusive, and a total output from the mines of eastern Ontario for the same periods of only 24,767 tons.

## MINES IN ONTARIO.

Ontario deposits.

Apatite mining commenced in Ontario at a comparatively early date. As far back as 1860 a shipment of 100 tons was made from the mines in the township of North Burgess; or about 10 years before actual mining operations were commenced in the province of Quebec.

The mining centres in this province may be described under three heads as regards locality, viz.: those of North Burgess between the Rideau lake and the town of Perth; those of the county of Renfrew; and those of the Kingston district, which includes the townships of Bedford, Storrington and Loughborough.

Renfrew township.

In the county of Renfrew the apatite deposits are practically confined to the townships of Ross and Sebastopol. Of these the mines which were opened nearly 25 years ago are the following:—

Elliott's mine, lot 7, range I, Ross, the mineral occurring in disseminated crystals in calcite, with other crystals of pyroxene, scapolite and titanite.

Cole's mine, lot 13, range VI, Ross, apatite in crystals in calcite.

Park's mine, lot 23, range XII, Sebastopol, crystals in calcite.

Meany's mine, lot 31, range XI, Sebastopol, in crystals with pyroxene in calcite.

Smart's mine, lot 31, range X. apatite in crystals in calcite.

Turner's mine, on island in Clear lake, apatite in crystals in calcite.

All these deposits are clearly of the vein type; and while in most cases are of small economic value, except as mineral localities, from several of the openings, notably in that south of Eganville, a large quantity of apatite was extracted, some of the crystals being of large size. Nowhere was there any indication seen of the large pockety deposits of the massive variety found north of the Ottawa.

In the Burgess district, the occurrences of the mineral are frequent and in some of the mines were quite extensive, so that this area was an important producer for some years. The mineral is found both in the contact vein form and as pockets in the mass of the pyroxene when such dykes are of good size. The greater number of the openings which have been made in the rocks of the district are however sunk on the vein or contact deposits.

In Gordon Broome's report, 1870-71, and in Vennor's report, 1873-74, a large amount of detailed information as to the working of the North Burgess mines is given with full descriptions of the numerous openings in the several areas. The greatest number of these are found on range VIII, from lots A, to lot 7, on the north side of Otty lake. Mining operations were carried on at intervals on lots 11 and 12, range VII; on lots 9, 10, 11, 12, 18, 19, 20, range VI; on lots 4, 8, 9, 10, 16, 19, 20, 21, range V, which include practically all the known deposits in this township. In the township of North Elmsley to the east, apatite is found on lots 25, 26, 27, range VIII, and on lot 30 range VI. In South Burgess it is found on lot 2, range IV. North Burgess.

It is not necessary to repeat here the various descriptions of the several areas in this district as contained in the reports just mentioned. From the details there given at the date of the workings, as well as from recent examination it is evident that the occurrences in this area are similar to those seen in the Wakefield and Gatineau districts rather than to those which occur on the Lièvre. While mining from surface pits, at slight expense, produced a fair amount of high grade apatite, mostly in the form of crystals, it was found that the expense of sinking shafts and driving drifts was usually too great to warrant long continued operations, so that while the surface openings were very numerous, mining gradually declined as the more readily accessible deposits were extracted. Several of the most important areas have since been re-opened for mica and the associated apatite has been saved as a by-product, but during the past year only one mine of mica was being worked.

## Mines of the Kingston District.

Kingston district.

In the mines of the Kingston area, which extended as far north as the vicinity of Sharbot lake on the Canadian Pacific railway, similar conditions have been observed to a large extent. Some of the crystals are of larger size than any yet found in the Burgess district and have yielded a large amount of excellent apatite.

In the township of Bedford, workable deposits have been opened up near Bobs lake on lots 32, 33, 34, range VII; lot 28, range VIII; lots 4 and 6, range XIII; lot 3, range XII; lot 7, range VII; lot 6, range IV; lot 4, range II.

### Township of Storrington.

Lot 8, range XV; (Buck Lake mine); lot 23, range XV, (Opinicon lake.)

### Township of Loughborough.

Lots 11, 12, 14, 16, range VIII.

Lots 4, 5, 10, 11, 12, 13, 15, 17, range IX.

Lots 7, 8, 10, 13, (Foxton mine); 19, 24, range X.

Lots 8, 9, 10, 15 24, range XI.

Lots 19, 22, 24, range XII.

Lots 24, 25, range XIII.

### Township of North Crosby.

Lot 19, range II; lot 20, range III; lot 21, range X; lot 29, range IX.

### Township of Oso.

Lot 6, range I; (St. George Lake mine.)

Lots 1 and 2, range V: (Crow lake.)

Lot 14, range VI; lot 4, range VIII.

### Township of Hinchinbrooke.

Character of these deposits.

Lots 29, 30, range I. (Eagle Lake mines. Boyd Smith.)

The above list comprises most of the mining areas in the Kingston district. In some, as on the Boyd Smith property, the apatite is

found in pockety chimneys similar to certain occurrences in the Lièvre district, but in the greater number it is usually associated with mica and calcite. The country rocks of all the area are practically similar throughout, consisting of the usual grey and reddish gneiss, with some quartzite and limestone, all of which are traversed by dykes of pyroxene, diabase and pegmatite. Several of these mines were opened to depths of over 200 feet as at Opinicon and Buck lakes, while in other cases the work done was by shallow pits. The great bulk of the output was apparently from the crystallized variety, though some quite large deposits of the massive variety, both red and green were extracted.

It is impossible to obtain the details of the workings at most of these localities. At the time of the recent visits the mining had long been abandoned, the excavations were full of water, and the information regarding the structure and nature of the deposit could only be obtained from the surface workings and from the dump material.

Calcite replaced by apatite.

At several of the mica mines, notably the Sydenham mine, of the General Electric Co., formerly worked for apatite, (the Smith and Lacey) some interesting features were observed. The mica was found to occur sometimes in the mass of the pyroxene after the manner of apatite elsewhere, and sometimes as crystals in calcite associated with crystals of apatite. In places in the same shaft the calcite was found to give place to apatite, and in this case the mica was disseminated in the latter in the same manner as in the calcite.

In many of the localities throughout the district the quantity of the mineral was not sufficient to warrant an extensive mining plant, and the work of drilling and hoisting was carried on for the most part by hand labour. The extraction of the mineral was often done by the farmers of the district, who in spare time from their regular farm work were able to extract considerable amounts of the mineral in a comparatively simple manner; but when the surface pits reached a depth beyond which this process was not practicable the mining was abandoned in favour of some more accessible locality. In certain places where the apatite crystals were very thickly distributed through the calcite their extraction was rendered possible and profitable for a time; but when, as is often the case, they were sparingly disseminated the expense attending the mining was such that all possible chance of profit was eliminated.

Isolated occurrences of apatite have been reported from several townships other than those mentioned, but apparently the quantity in

these localities was never sufficient to warrant the expenditure of much capital in their development.

As an illustration of the rise and decline of one of the leading mining industries of the province of Quebec and eastern Ontario the following figures taken from the Report of the Mining branch of the Department for 1895 may be given. The period extends from 1878 to 1894, both inclusive, the amounts prior to the first mentioned date being for Ontario, probably not more than 1,000 tons annually.

Output.

## EXPORTS OF PHOSPHATE.

| Year. | Ontario. | | Quebec. | |
|---|---|---|---|---|
| | Tons. | Value. | Tons. | Value. |
| 1878..... | 824 | $12,278 | 9,919 | $195,831 |
| 1879..... | 1,842 | 20,595 | 6,604 | 101,470 |
| 1880..... | 1,387 | 14,422 | 11,673 | 175,664 |
| 1881..... | 2,471 | 36,117 | 9,497 | 182,339 |
| 1882..... | 568 | 6,338 | 16,585 | 302,019 |
| 1883..... | 50 | 500 | 19,666 | 427,168 |
| 1884..... | 763 | 8,890 | 20,946 | 415,350 |
| 1885..... | 434 | 5,962 | 28,535 | 490,331 |
| 1886..... | 644 | 5,816 | 19,796 | 337,191 |
| 1887..... | 705 | 8,277 | 22,447 | 424,940 |
| 1888..... | 2,643 | 30,247 | 16,133 | 268,362 |
| 1889..... | 3,547 | 38,833 | 26,410 | 355,935 |
| 1890..... | 1,866 | 21,329 | 26,591 | 478,040 |
| 1891..... | 1,551 | 16,646 | 15,720 | 368,015 |
| 1892..... | 1,501 | 12,544 | 9,981 | 141,221 |
| 1893..... | 1,990 | 11,550 | 5,748 | 56,502 |
| 1894..... | 1,980 | 10,560 | 3,470 | 29,610 |
| 1895..... | ..... | ..... | 250 | 2,500 |
| | 26,766 | $260,874 | 280,000 | $4,752,388 |